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GOLD CREEK POND EXPERIMENT

Kittitas Conservation Trust (KCT) and their consultant Natural Systems Design (NSD) conducted a hydrologic study of Gold Creek in 2013 to determine and evaluate casual mechanisms contributing to dewatering of the creek directly above Gold Creek Pond during the summer months. Approximately 1.25-miles of Gold Creek dries up every year when the threatened Gold Creek Bull Trout (*Salvelinus confluentus*) population migrates upstream to spawn in the upper watershed. The hydrologic study will be used to develop conceptual restoration designs that restore perennial flow conditions in Gold Creek during this critical time period, and improve in-stream habitat within the reach.

Based on the initial findings of the study in 2013, a more detailed understanding of the spatial and temporal characteristics of dewatering emerged, and the possible role of historic disturbances. Several potential contributors to dewatering of Gold Creek were identified, including:

1. Modification of natural hyporheic groundwater within the valley due to hydraulic gradient imposed by Gold Creek Pond,
2. Significant widening of the active channel from historic logging, increasing infiltration rates,
3. Buried drainage line,
4. Modification of natural groundwater flow resulting from Heli's Pond,
5. Reduced base flow conditions due to climate change.

Gold Creek Pond was created as rehabilitation of a gravel extraction pit used during construction of I-90. Prior to this disturbance, the area where the pond and associated facilities are located was a forested wetland complex. Conversion from the forested wetland complex to an artificially regulated pond occupying up to 72% of the valley width has resulted in significant ecological degradation both locally and in the vicinity of the Pond. The outlet channel sets the elevation of the Pond by directing groundwater contributing to the Pond to overland flow down the outlet channel. The water surface elevation of the Pond was found to vary only 0.3-feet from June to September, while groundwater elevations varied by as much as 5.5-feet during the same time period. During the course of field monitoring during the 2013 season, groundwater was observed issuing from the northern bank of Gold Creek Pond, approximately 2-feet above the water surface of the Pond. This phenomenon clearly indicates that at northern end of the pond, groundwater levels are suppressed at least 2' below natural levels due to the Pond, and the effect extends up-gradient in the eastern floodplain to Gold Creek (Figure 1), however at a decreasing magnitude. The orientation of the upstream side of the Pond, extending up the eastern side of the valley relative to the western side, was found to draw groundwater from Gold Creek toward the eastern side of the valley, further contributing to dewatering in the creek (Figure 2). These findings highlight the importance of Gold Creek Pond in influencing the local groundwater conditions in Gold Creek valley, and how that influence is likely contributing to seasonal dewatering of Gold Creek. The primary goal of the proposed experiment is to quantify the degree to which the Pond is contributing to dewatering of the creek.

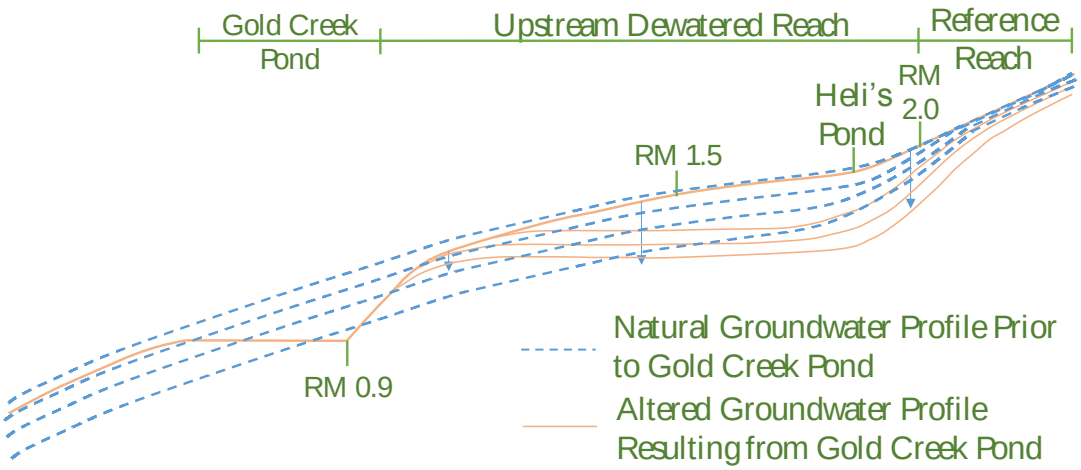


Figure 1. Conceptual groundwater profiles down Gold Creek valley. Dashed blue lines depict the historic, pre-disturbance groundwater profile, and how it declines during the summer months. Solid orange lines depict the current groundwater profile, and how it declines during the summer months.

See end of document for Figure 2

Preliminary restoration actions have been developed based on the findings of the 2013 hydrologic assessment, which include:

1. Modification/Restoration of Gold Creek Pond,
    - Partial or complete filling to restore native floodplain topography and alluvial hyporheic zone
    - Raise pond water elevation sufficient to simulate natural groundwater table
2. Restore narrower historic channel width,
3. Plug buried drainage line,
4. Restore floodplain at Heli's pond, completely or partially filling pond
5. Install stable in-stream large wood to improve in-stream habitat, principally pools and cover

In order to prioritize options related to the influence of Gold Creek Pond, additional monitoring is underway which can best address the Pond's effect by temporarily raising water elevations (in the pond) during the period of creek dewatering. Funding was made available to collect an additional year of hydrologic data (summer 2014) to compare with the 2013 results, and to further investigate the role of Gold Creek Pond by seeing if raising water elevations in the pond reduce the extent of dewatering in Gold Creek by raising the groundwater table. An experiment was developed that could provide valuable information about how Gold Creek Pond effects groundwater elevations upstream and downstream of the Pond, where dewatering of Gold Creek initiates.

The proposed experiment will temporarily raise the water surface elevation (wse) of Gold Creek Pond, approximately 2.5-ft, and measure the response of at established groundwater wells and stream stations in Gold Creek. It is hypothesized that by raising the wse of Gold Creek Pond, there will be an increase in the groundwater wse that is also reflected in Gold Creek water levels. The intent of the experiment is to evaluate the magnitude of wse rise at the up-gradient monitoring locations, and if it is sufficient to re-water reaches of Gold Creek that were dewatered prior to starting the experiment. The up-gradient response will be evaluated spatially (vertical increase in wse at each monitoring location, horizontal variation in increase based on monitoring location relative to the Pond), and temporally (vertical and horizontal variation in wse over time) to determine the effect of the experiment.

Continuous data will be collected in Gold Creek Pond and all of the groundwater and surface water stations during the experiment. This includes the anticipated 2-weeks it will take to raise the wse of the Pond 2.5-feet. The higher wse will be maintained for approximately 1-2 weeks, and then lowered over about 3 days to it pre-existing wse. Correlations over time between the Pond wse and that recorded at

the monitoring locations will be used to evaluate the effect of rising the Pond, including any lag time in the response relative to the distance from the Pond, and used to project the correlations to estimate response to a rise greater than the 2.5-feet during the experiment (Figure 3).

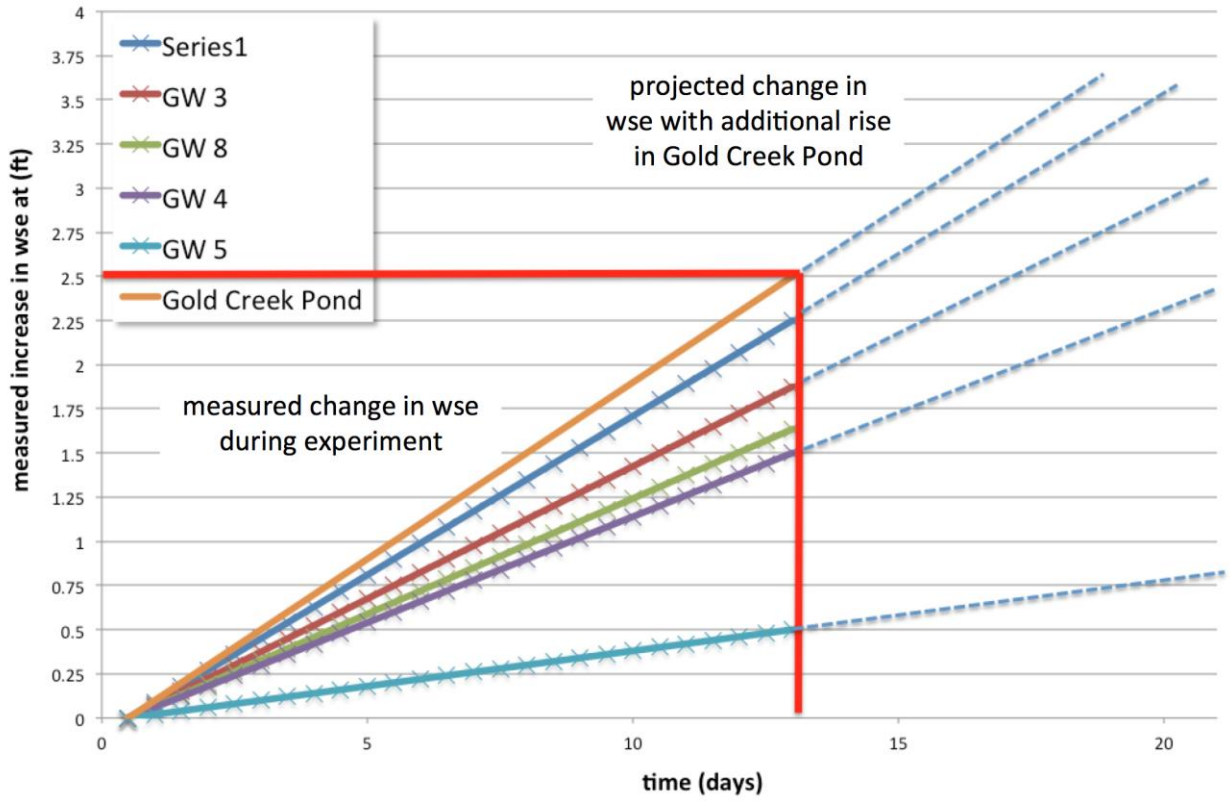


Figure 3. Figure depicting conceptual rise in wse during the experiment in Gold Creek Pond, and at the groundwater stations up-gradient of the Pond. The trend of increasing wse at all locations can be projected to estimate expected rise if additional rising of the wse of the Pond is desired. This figure does not depict the expected lag-time in response in the up-gradient wells, and is simply showing a linear increase over time, with wells further from the Pond experiencing less increase in wse.

SIMULATED CONDITIONS DURING THE EXPERIMENT

By raising the wse of the Pond, the experiment will simulate the alteration of groundwater flow, to varying degrees, resulting from the proposed modifications/restoration actions for Gold Creek Pond including:

1. Complete or partial fill of Pond - conversion back to historic wetland complex,
2. Increase Pond elevation – permanent rise of pond, re-configure outlet channel location.

A partial fill of the Pond is under consideration as an alternative restoration action at Gold Creek Pond. This alternative would include selectively filling the northeastern corner of the pond where it extends further up-valley relative to the northwestern corner (re-align the northern edge of the Pond to be perpendicular to the axis of Gold Creek Valley). This approach would reduce the lateral gradients (movement of groundwater from Gold Creek toward the eastern side of the valley) upstream of the pond resulting from the orientation of the Pond relative to the axis of Gold Creek valley, but would have less overall increase in groundwater elevations compared to filling the entire pond. The experiment will not mimic this restoration alternative. To fully mimic groundwater conditions associated with completely

filling Gold Creek Pond, the wse of the northeastern corner of the Pond would need to be higher than the northwestern corner, as it is further up-valley relative to the northwestern corner of the Pond.

Complete Fill

The restoration alternative of completely filling Gold Creek Pond includes restoration of the site back to the historic forested floodplain wetland complex that was present prior to gravel extraction in the valley and conversion to the current regulated Pond. By filling the Pond, the natural groundwater profile would be restored through the area where the Pond is located. Currently, the Pond lowers groundwater elevations below that which would be present naturally (Figure 1). The relative magnitude of the lowering effect is greater on the up-gradient side of the Pond than on the down-gradient side. This lowering of the groundwater as a result of Gold Creek Pond extends up-gradient into the eastern floodplain of Gold Creek, however the degree and extent of lowering up-gradient is uncertain. By raising the wse of the Pond during the experiment, we will mimic the increase in groundwater elevation that would occur if the Pond were to be filled completely. The increase in wse of up-gradient groundwater and surface water stations will provide a proxy for anticipated increases associated with filling the Pond.

Increase Pond Elevation

An alternative under consideration is to permanently raise the wse of Gold Creek Pond and relocate the outlet channel to Gold Creek. If the depression of up-gradient groundwater elevations resulting from the current Pond wse is such that they can be restored to a level that will improve dewatering conditions in Gold Creek, permanently increasing the wse of the Pond would provide a cost effective means to address dewatering in Gold Creek. In addition to permanently increasing the wse of the Pond, the location of the outlet channel would be reconsidered to move the confluence with Gold Creek further upstream, near the northwestern corner of the Pond, to improve the length of Gold Creek with perennial outflow from the Pond. Currently, Gold Creek remains perennial downstream of the confluence with the outlet channel, as it provides perennial outflow from the Pond. Simply moving the confluence upstream will ensure a longer section of Gold Creek will remain perennial and reduce the length of channel that currently experiences dewatering seasonally. The downstream dewatered section of Gold Creek (located immediately upstream of the confluence with the outlet channel) expanded to 0.16 miles long during the 2013 season. Upstream of this dewater lower reach, the channel remained wetted for an additional 0.29 miles, however this section of channel remained inaccessible to Bull Trout owing to the downstream dewatered reach. Relocating the outlet channel upstream could convert up to 0.45 miles of Gold Creek to perennial flow.

The experiment would mimic the anticipated increase in wse in the up-gradient groundwater and surface water stations that would occur is the Pond elevation were permanently increased. Based on the relationships measured between the Pond elevation and the corresponding monitoring locations throughout the experiment, potential Pond elevations greater than the 2.5-feet increase measured during the experiment will be evaluated by projecting relationships forward (Figure 3).

POTENTIAL IMPACTS DURING THE EXPERIMENT

The potential impacts to the primary constituent elements (PCE) of Gold Creek Bull Trout related to the experiment have been considered in developing the study design for the experiment. The PCE's considered include:

1. Springs, seeps, groundwater sources,
2. Migratory corridors,
3. Abundant food base,
4. Complex habitats,
5. Water temperature
6. Substrate quality,

7. Natural hydrograph,
8. Water quality and quantity.

The potential impacts to these PCE's resulting from the experiment are all considered within Gold Creek, and not in the outlet channel.

Springs, Seeps, Groundwater Sources

No Negative Impacts - There are no anticipated negative impacts to springs, seeps, or groundwater sources associated with Gold Creek resulting from the experiment. The experiment will raise the wse of Gold Creek Pond, which will increase/supplement groundwater elevations adjacent to the Pond.

Migratory Corridors

Minimal to No Negative Impacts, Potential Benefits - The migration corridor up Gold Creek currently ends at the confluence with the outlet channel during dewatering in the creek. The experiment will reduce flow in the outlet channel to induce the rise in the wse of the Pond. This reduction in flow is anticipated to last for 2-weeks, during which time flow in the outlet channel will diminish by 1-cfs. After the Pond has reached the desired 2.5-ft increase in wse, flow in the outlet channel will return to the "natural" flow. After several days, the wse of the Pond will be gradually lowered back to the pre-experiment level, during which time flow in the outlet channel will be greater than the "natural" flow. Downstream of the confluence with the outlet channel, Gold Creek will have diminished flow (by up to 1-cfs), however this will not decrease the migratory corridor.

During the experiment, reaches of Gold Creek that are dewatered may become re-watered as a result of the experiment, resulting in a positive increase in migratory corridor length. Should dewatered sections of Gold Creek become accessible to migrating Bull Trout during the experiment, we propose to extend the duration of the experiment to maintain flow/water in Gold Creek until natural inflow from upstream is sufficient to maintain flow in the channel.

There are no anticipated negative impacts to the migratory corridor resulting from the experiment. The experiment will maintain flow (reduced by 1-cfs) in the outlet channel throughout the experiment, which will maintain the current migratory corridor in Gold Creek.

Abundant Food Base

Minimal to No Negative Impacts - Gold Creek Bull Trout feed on macro and micro-invertebrates in Gold Creek, and access to these flood sources is limited to the wetted channel. Because there will be a decrease in flow (1-cfs) in the outlet channel for approximately 2-weeks, there will be a reduction in flow in Gold Creek. This reduction in flow will decrease the wetted channel area and potentially available food sources. However, the anticipated reduction in flow is well within the natural variation in Gold Creek, and is not anticipated to isolate a significant area of the channel due to lower flow during the experiment.

Complex Habitats

No Negative Impacts - There are no anticipated negative impacts to complex habitats in Gold Creek resulting from the experiment.

Water Temperature

No Negative Impacts, Likely Benefits - The water temperature of Gold Creek is currently influenced by contributing flow from the outlet channel from Gold Creek Pond. Flow in the outlet channel tends to be warmer than Gold Creek due to solar radiation warming the Pond surface waters, where the outlet channel draws water from the Pond. Because the experiment will temporarily reduce the flow in the

outlet channel as the wse of the Pond is raised, the contributing warmer water from the outlet channel will be diminished. This will have a positive cooling effect in Gold Creek as the Pond wse is raised.

Substrate Quality

No Negative Impacts - Minor disturbance to a very small portion (~300 ft^2) of the outlet channel bed is anticipated during installation of the temporary dam. However, there are no anticipated impacts to substrate quality, as any disturbed sediments will fall out of suspension prior to reaching Gold Creek.

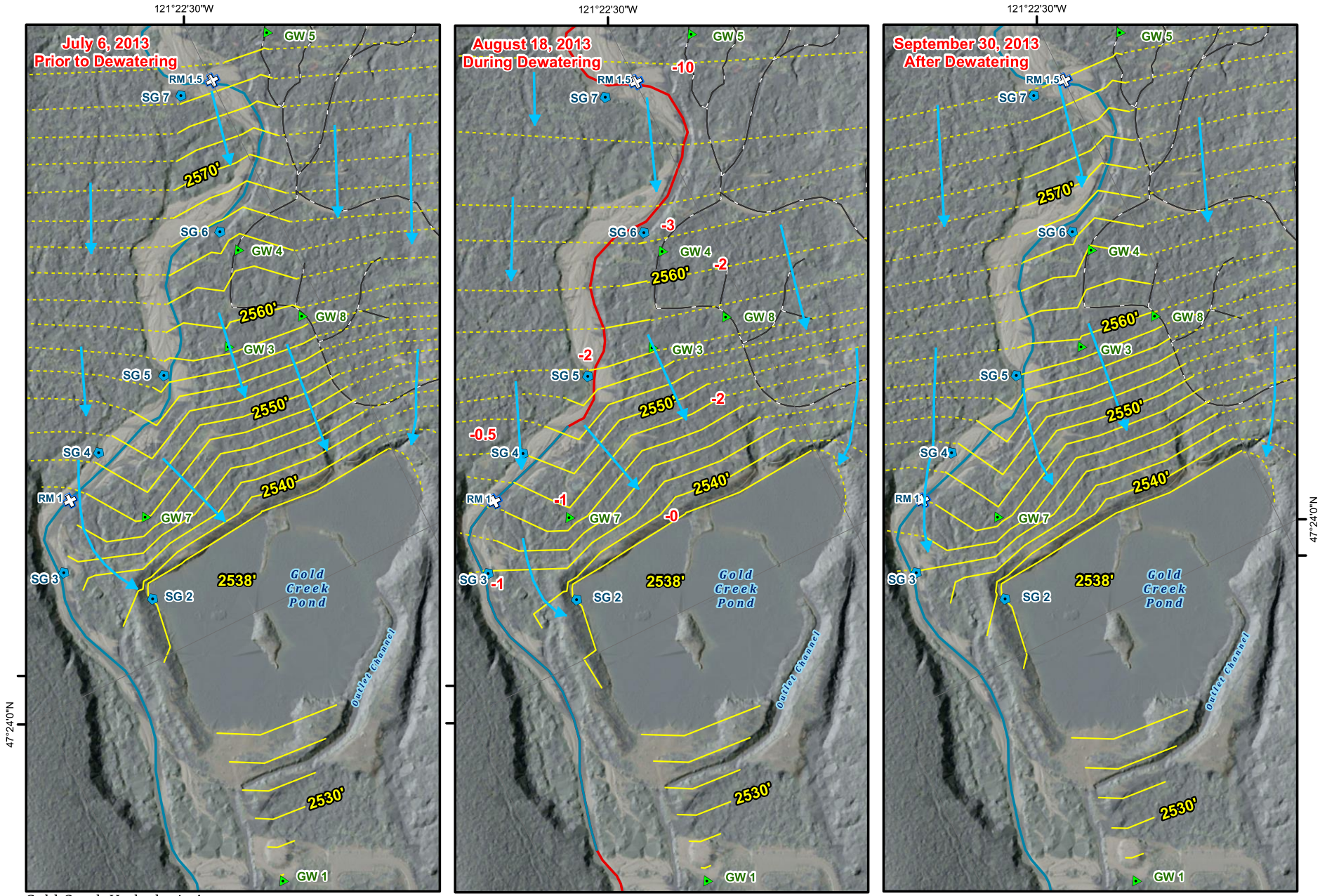
Natural Hydrograph

No Negative Impacts, Potential Benefits - The natural hydrograph for Gold Creek is currently modified by Gold Creek Pond and the outlet channel. The current, modified hydrograph will be reduced in magnitude by 1 cfs in Gold Creek downstream of the confluence with the outlet channel during the experiment as the Pond wse is raised. During the experiment, reaches of Gold Creek that are dewatered may become re-watered as a result of the experiment, resulting in a positive impact on the natural hydrograph. Should dewatered sections of Gold Creek become accessible to migrating Bull Trout during the experiment, we propose to extend the duration of the experiment to maintain flow/water in Gold Creek until natural inflow from upstream is sufficient to maintain flow in the channel.

Water Quality and Quantity

No Negative Impacts, Potential Benefits - The potential impact to water quality and quantity will vary during the duration of the experiment. At the start of the experiment flow in the outlet channel will be reduced by 1-cfs to initiate a rise in the wse of Gold Creek Pond. It is expected to take up to 2-weeks to retain sufficient water to achieve the 2.5-ft rise desired. During this time period, the flow quantity from the outlet channel contributing to Gold Creek will be 1-cfs less that under "natural" conditions. However, because the flow in the outlet channel is warmer than that in Gold Creek, the diminished flow quantity will reduce water temperatures in Gold Creek, a positive impact. Once the 2.5-ft rise in the Pond is achieved, the flow in the outlet channel will return to its "normal" rate, and there will not be any change in water quality or quantity in Gold Creek. As the wse of the Pond is lowered at the end of the experiment, flow in the outlet channel is be greater than "normal" conditions, having a positive benefit to water quantity in Gold Creek. However, the greater contribution of warmer water from the outlet channel will have a negative impact on water quality in Gold Creek. The changes in water quality and quantity as the wse of the Pond is increased and lowered are anticipated to be minimal.

At any time during the experiment, reaches of Gold Creek that are dewatered may become re-watered as a result of the experiment, resulting in a positive impact on water quality and quantity. Should dewatered sections of Gold Creek become accessible to migrating Bull Trout during the experiment, we propose to extend the duration of the experiment to maintain flow/water in Gold Creek until natural inflow from upstream is sufficient to maintain flow in the channel.



Gold Creek Hydrologic Assessment

Figure 2 : Water Surface Elevation Maps

Data sources: 2012 LiDAR Watershed Sciences, Inc.; USDA NAIP 2011; WA DNR

15 River Mile
Wetted Channel
Dewatered Channel
Roads
-10 Decrease in wse (ft)
Surface Gauge
Groundwater Well
2 ft Water Surface Contour
Extrapolated 2 ft Water Surface Contour

0 1,000 Feet

Kittitas Conservation Trust

Natural Systems Design